We appreciate the opportunity to offer our input on the first draft Delta Science Plan. We believe the Science Program has put together a very strong first draft Plan, particularly in light of the progarm's resource and temporal constraints. In an effort to provide comments that are useful and specific, we are providing redline versions of several sections of the draft Plan. The comments below are intended to elaborate upon the redline materials.

1) The draft Plan references use of "best available science." Previous authors have described some common characteristics of best available science, and the draft Plan reproduces "steps for achieving the best science" and "criteria for best available science" in Appendix 4. But, the draft Plan could go further and recognize that there are discrete information elements, sources of information, and analytical tools that, if consistently engaged, contribute to the use of best available science, or, better, reliable knowledge, upon which defensible management actions can be based.

In particular, research efforts, monitoring results, and modeling efforts are most reliable if they:

- (i) are spatially explicit, reflecting geographic variation and site-specific, in situ environmental conditions,
- (ii) test discrete hypotheses (that is, attempt some form of falsification exercise),
- (iii) are clear on assumptions and uncertainties, clearly state limitations of findings to the extent reasonable,
- (iv) are set in an appropriate spatial context (not constrained or bounded, as in most habitat conservation plans),
- (v) build on available ecological theory,
- (vi) use all available pertinent information, including citation of previous work that both supports and does not support findings, and attempts to explain discrepancies (also considers all available information, and ranks/grades that information based on the reliability of the source – published, unpublished, agency publications, etc.),
- (vii) emerge from an explicit conceptual model of the targeted species and its relationship to the environmental attributes of its habitat, including stressors,
- (viii) use analytical tools appropriate to the problem being solved,
- (ix) use a structured approach, particularly life-cycle models and population viability analysis, to exercise available data, and
- (x) employ a rigorous specification of response and environmental variables.

This list, if religiously employed, would facilitate Delta Science Program efforts to avoid misuse of technical terms, employ of selective data, the tendency to sub-sample populations, default to use of relict analytic tools, dependence on design-free monitoring, frequent data mining as proxy for experimental design, and recurring presentations of correlations masquerading as causation.

2) The draft Plan should explicitly give priority attention to research, monitoring, and modeling efforts that are designed to answer questions and otherwise address uncertainties that directly contribute to management decisions and inform policy initiatives. Basic research will continue to be an essential element in the Delta Science Program, but in our view it should not be the Program's emphasis, at least until the more vexing uncertainties that stymie management are directly addressed by experiments and other data collection schema. *We believe this point can be addressed by making the redline change proposed to Chapter 1 of the draft Plan*.

Recurring problems in the translation of research findings from the scientific literature into management-friendly guidance include 1) incomplete presentation of available information, which can lead to conclusions that would not be drawn if the complete information base had been considered, 2) misinterpretation and/or misrepresentation of analyses or findings drawn from analyses in published studies, 3) inappropriate emphasis of findings, and, frequently, absence of consideration of uncertainties and study limitations that attend those findings, 4) mistaken presumption that conclusions presented as part of an empirical study are scientifically valid if the study appears in a peer-reviewed, "scientific" journal, and 5) an assumption that conclusions are more robust and defensible when the quantity of data, extent of analyses, or number references are greater. These inherent impediments to effective and efficient translation of science into reliable knowledge and then into meaningful management guidance are circumvented when studies are designed to directly and explicitly address management uncertainties.

3) The draft Plan should recognize that the omnibus definition of science that pervades conservation planning in the Delta has confused management planning, misdirected management actions, and failed to benefit imperiled species. Science is not the appropriate term for all matters technical, exercises that count and measure things, and any efforts that has a biological or hydrological component. The draft Plan should encourage and prioritize and offer its prioritized support to studies, surveys, and modeling approaches that are couched as testable hypotheses, and can be used to reject conservation planning alternatives that are likely to be ineffective before valuable resources are wasted. *We believe this point can be addressed, in part, by making the redline change proposed to Chapter 1 of the draft Plan and including an explicit definition of science in the Glossary*.

4) The draft Plan can more assiduously declare the preeminent role of adaptive management in the overall scientific venture in the Delta. It is the forum in which the grand challenges will be met; it offers the framework in which they will be engaged. We are heartened to see a "next level" of detail that describes the "scientific" challenge that is embodied in adaptive management – the outer ring of explanatory boxes in Figure 3-1 adds valuable detail to the adumbrated version of adaptive management presented in the Delta Plan. We think the draft Plan provides an appropriate vehicle to add further details and guidance in order to avoid the same pitfall that has led to failed adaptive management in many other

circumstances, namely, an intuitively appealing but overly simplistic characterization of the concept, which allows virtually any conduct to qualify as adaptive management. The technical aspects of the details are discussed in more detail on pages 9-13 in the attached, submitted manuscript. *We believe modest redline adjustments proposed to Chapter 3, Figure 3-1, and Appendix 3 add further detail and guidance that will increase the likelihood of success in implementing adaptive management*.

5) The draft Plan should emphasize that monitoring is front and center within the science program's purview. Monitoring is a form of research. We believe it would be beneficial if the draft Plan were to state clearly that the monitoring schema for the Delta need to undertake a sequence of requisite procedural steps in a structured approach to its design and implementation. Taking advantage of available reliable knowledge, including time-series data from multiple long-term assessment efforts, agency-generated (DRERIP) conceptual models, and pertinent results and findings from research efforts, any new or revised monitoring efforts should:

- Identify and characterize the full complement of environmental attributes, including water-quality, physical landscape, and biotic factors that are believed to affect the status and population trends in the Delta's native, at-risk fishes and other ecosystem elements of concern.
- Facilitate efforts to rank the environmental factors according to their degree of impact or irreversible consequences on resources.
- Access available conceptual models of the species and ecological systems of concern, outlining pathways from water-quality stressors to ecological effects on fishes and other environmental attributes.
- Select an "optimal" set of direct measures and environmental-condition indicators that are efficient at detecting effects on target species and essential resources upon which those species depend.
- Determine detection limits for those measured variables and condition indicators.
- Establish contingent decision values (thresholds or trigger points) for the measured variables and indicators.
- Establish clear connections between monitoring outputs and prospective management decisions.

In support of these program elements, monitoring efforts would identify response variables drawn from species of conservation concern, resources upon which one or more of those species depend, and valid surrogate measures for both. The effort should identify and list the fullest possible array of candidate stressors believed to affect the population dynamics of desired species – water quality variables (including abiotic factors, toxic contaminants, and nutrients), landscape characteristics (morphological and bathymetric factors, physical and biotic resources adjacency and connectivity), and food web structure and composition (including prey and predators).

Essential considerations in the next-generation monitoring schema will ensure that continuity is provided with existing monitoring programs to the extent necessary to prevent loss of important time trend data; that all pertinent aspects of Delta ecosystems and the stressors that affect them are integrated into sampling frames; that sampling minimizes survey bias generated by tidal stage, time of day, water-body depth, and other bias-inducing factors; and temporally and spatially coincident sampling is carried out so as to provide data that supports analyses of linkages among important elements of the ecosystem, including the condition of the Delta's desired fishes. *We believe these points can be addressed by redline adjustments proposed to Chapter 4*.

6) The draft Plan's invocation of "one Delta, one science" has the potential to draw misdirected ire. As you well know, the history of science is a history of different explanations of natural and social phenomena vying for primacy over one another. This is reflected in Kuhn's *The Structure of Scientific Revolutions*. Rigorous discourse among scientists routinely upends the status quo across disciplines. For example, the concept of "the balance of nature" was widely accepted, textbook science a few decades ago but has since been falsified. More recently, the media covered findings by physicists that challenge Heisenberg's uncertainty principle, which proposes the existence of a limit of the extent to which two properties of a particle can be known simultaneously. These sorts of advancements in science are stifled by the presence of a dominant paradigm. To an extent, this is impossible to avoid, but institutionalization of a dominant paradigm would exacerbate rather than ameliorate this phenomenon. It is our firm belief that your intent is to create a scientific community that welcomes challenges to the status quo rather than rejecting them. *We believe this point can be addressed by redline adjustments we proposed to Chapter 1, box 1-1*.

7) We recognize that the draft Plan is a Science Plan rather than a Public Participation Plan. That said, we believe a role for interested parties – particularly those that have pertinent technical capacity or expertise – is an essential component of a durable Science Plan. *We believe this point can be addressed by modest redline adjustments we proposed to Chapters 1 and 2*.

Introduction

Around the world, high expectations exist for science to enlighten and steer natural resources management issues in a direction of sustaining critical ecosystem services, functions, and processes. Implementation of the Delta Reform Act and the Delta Stewardship Council's Delta reliable Plan depend on science support (Water Code §85020(h)) to achieve the coequal goals of a more water supply for California and protecting, restoring, and enhancing the Delta ecosystem (Water Code §85054). Significant scientific investments have been and continue to be made to understand the Delta system to inform water management and environmental decisions. But~~However,~~ despite the commitment of substantial resources to support~~a rich history of~~ scientific stud~~y~~ies and data sets that span as many as four decades in some cases~~more than 40 years of aquatic monitoring~~, insufficient data collection schema and modeling efforts as well as a lack of integration, coordination, cooperation and communication weaken efficient development and effective use of best available science to inform decision making. A new path forward is needed to achieve the vision of One Delta, One Science (Box 1-1).

> BOX 1-1 VISION
> The Delta Science Plan aims to achieve the vision of 'One Delta, One Science' – an open Delta science community that works collaboratively to build a shared state of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. This vision of an open scientific community is intended to foster an environment that promotes a vigorous exchange of ideas and allows for development, adoption, and dismissal of competing paradigms. Its purpose is to promote, rather than stifle, scientific advancements based on research, monitoring, and modeling.

A Delta Science Strategy

A Delta Science Strategy is essential for achieving the vision of One Delta, One Science and for providing the science needed to support achievement of the coequal goals of the Delta Reform Act. To do so, the strategy must give priority attention to research, monitoring, and modeling efforts that are designed to directly inform decision-making (for example, by answering discrete questions or reducing uncertainties) by policy-makers and managers. This Delta Science Plan is one of three elements of a comprehensive Delta Science Strategy: 1) The Delta Science Plan, 2) The Science Action Agenda (Action Agenda), and 3) The State of Bay-Delta Science (SBDS) (Figure 1-1).

The Delta Science Plan

The Delta Science Plan articulates a vision for Delta science and a broad, durable framework for organizing and integrating Delta science. It creates the institutional capacity to support, enhance and network all science programs ~~that~~ established to contribute to Delta Science. The Delta Science Plan supports infrastructure for making the highest caliber science available for Delta water and environmental decision making, including adaptive management as required by the Delta Reform Act and the Delta Plan (Box 1-2). The Delta Science Plan covers the geographic extent of the Sacramento-San Joaquin Delta (as defined in Section 12220 of the Public Resources Code) and Suisun Marsh (as defined in Section 29101 of the Public Resources Code) and ~~may~~ also addresses larger-scale processes, functions, and stressors outside its primary geographic focus area that influence conditions and organisms within the Delta.

Implementation of the Delta Science Plan will provide independent, peer-reviewed, objective science products to inform Delta decisions aimed at achieving the coequal goals, but expressly will not pass value judgment on the trade-offs between different decisions. It also recognizes the needs for agencies to meet their regulatory responsibilities.

The Delta Science Plan is developed by the Delta Science Program in close collaboration with federal and State agencies, local government, scientists and stakeholders. It is reviewed by the Delta Independent Science Board, the Delta Stewardship Council, federal and State agencies, local government, members of the Delta science community, and additional invited outside reviewers. It will be a living document that is updated every five years or more often if needed.

The Science Action Agenda (Action Agenda)

The Science Action Agenda (Action Agenda) establishes the prioritized science actions to achieve the objectives of the Delta Science Plan. The Action Agenda identifies the "grand challenges" and priorities for research, monitoring, data management, modeling, synthesis, and communication to address these challenges for a four-year period. The Action Agenda will be a shared agenda for science programs in the Delta that are housed in multiple federal, State, and local agencies, universities, and non-governmental organizations. It will serve as the common agenda for developing science work plans (e.g., the Interagency Ecological Program Work Plan). Activities in the Action Agenda will include multiple directed research activities and open competitive research solicitations. The Action Agenda will also support activities to predict potential outcomes of various management and intervention options, often referred to as "alternative futures." In doing so, the Action Agenda will support coordinated and transparent adaptive management. The Action Agenda~~SAA~~ will retain flexibility to conduct science around unanticipated specific events such as a flood, earthquake, levee failure, salt-water intrusion into the Delta or major releases of hazardous materials.

The Action Agenda will be developed through an open process by the Delta science community (including federal and State agencies, local government, academics, ~~stakeholders~~ and other interested parties) and the Science Synthesis Team (Action 2.2) under the leadership of the Delta Science Program. The Science Synthesis Team will provide high-level guidance for topics to be addressed in the Action Agenda based on key scientific uncertainties. The Policy-Science Team (Action 2.1) will provide high- level guidance on the prioritization of science actions based on "grand challenges" and decision makers' needs. Science action priorities identified at summits and through collaborative efforts for developing community tools (i.e., data management (Action 4.3.1.) and shared models (Action 4.4.1.) will also be incorporated into Action Agenda topics and prioritization. The Delta Lead Scientist has final responsibility for selecting and articulating the rationale for Action Agenda priorities. The four-year cycle of the Action Agenda will be aligned with the Biennial Bay-Delta Science Conference to maximize opportunities to openly engage the science community, policy makers, and managers involved in developing and applying scientific information for decision--making. The Action Agenda will be reviewed by the Delta Independent Science Board, consistent with its responsibility to provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta.

The State of Bay-Delta Science (SBDS)

The State of Bay Delta Science (SBDS) is a synthesized summary of the current knowledge related to the Delta from all sources of scientific understanding. Specifically, the SBDS communicates the state of knowledge to address the "grand challenges", including progress made on key research questions. It also guides updates to the Action Agenda.

The State of Bay Delta Science will be published every four years. SBDS will be written by relevant experts drawn, as appropriate, from academia, federal, state, and local agencies, and for-profit and non-profit non-governmental entities with guidance from the Science Synthesis Team. It is the responsibility of the Delta Science Program to produce the SBDS. The four-year cycle of SBDS will be aligned with the Biennial Bay-Delta Science Conference (offset from development of the Action Agenda). SBDS will be reviewed by the Delta Independent Science Board.

The Overarching Problem Addressed by the Delta Science Plan

Of the many science efforts in the Delta, few address more than a single objective or pragmatic question. The Delta Plan summarizes this problem:

> *"Currently, science efforts related to the Delta are performed by multiple entities with multiple agendas and without an overarching plan for coordinating data management and information sharing among entities. Increasingly, resource management decisions are made in the courtroom as conflicting science thwarts decision making and delays action. Multiple frameworks for science in the Delta have been proposed, but a comprehensive science plan that organizes and integrates ongoing scientific research, monitoring, analysis, and data management among entities has yet to be fully formulated."*

Despite the close working relationships of many individual scientists and the collaborative efforts of focused programs such as the Interagency Ecological Program (IEP), it is very difficult to track all activities on a given topic, including data generation, model development and calibration, and new results and insights gained. While coordination of Delta efforts occurs, fragmented approaches to planning, regulation and management threaten effective and efficient management of the Delta ecosystem (Hanak et al. 2013). A structure and process to facilitate sustained integration are distinctly lacking. This makes it very difficult to provide the needed broad knowledge base of scientific information synthesized from multiple sources, a variety of scientific disciplines and geographic areas, and across different time scales and jurisdictional topics. In addition, generally accepted and adequately supported organizational structures and processes do not exist for ongoing scientific synthesis. Not surprisingly, there are only a few examples of broad synthesis efforts in the Delta. These synthesis activities are essential to delivering the best available science needed to support policy and management decisions.

This Delta Science Plan respects the sovereignty of agencies, institutional missions, and legal mandates while providing a shared science plan for Delta programs. Implementation of the Delta Science Plan will enable scientists to be more productive through interagency collaboration, integration and the use of common tools. Where possible, this plan builds on existing organizational structures to provide this coordination, synthesis, and communication.

What are the Key Issues the Delta Science Plan Addresses?

Coordination and Integration of Delta Science - Current fragmentation of science institutions hinders efficient development and use of a common and trusted body of science for Delta decision making. These fragmented science institutions do not have the capacity to efficiently address "grand challenges" that will need rigorous science support to address the coequal goals (Box 1-3). This Delta Science Plan addresses "grand challenges" through a shared approach for organizing and integrating ongoing scientific research, monitoring, data management, analysis, synthesis and communication.

Science Synthesis - The lack of a collaborative mechanism for synthesis hinders the timely translation of information into usable knowledge. This plan will establish a Science Synthesis Team composed of scientists from academia, federal, state, and local agencies, and for-profit and non-profit non-governmental entities (facilitated by the Delta Science Program) tasked with integrating and synthesizing relevant research and current knowledge to inform ecosystem restoration and water management decisions (Action 2.2).

Science-Policy Communication - Communication channels between decision makers and the broad science community (comprising federal, ~~and~~ State, and local agencies, universities, non-governmental science programs and consultants) are currently limited. Furthermore, the roles of science (to inform decision making) and the roles of policy and managers (to prioritize and make decisions) are not always clearly understood. Challenges to communicate and develop a shared understanding of needs, opportunities, and roles at these interfaces have led to considerable frustration. This plan provides a new path forward for improving communication at these interfaces through establishing a Policy-Science Team, which includes Directors of federal and State agencies, Delta Science Leaders and select members of the Science Synthesis Team (Action 2.1). This team will facilitate shared understanding of policy priorities and scientific information and the direct communication of new understanding into actionable alternatives for management and policy changes.

Effective Adaptive Management- Past attempts to adaptively manage Delta water operations and habitat restoration have rarely covered the full adaptive management cycle ~~(Plan, Do, Evaluate and Respond)~~, which is elaborated upon in Chapter 3 and Appendix 3 of this Plan. There is a risk of not being able to attain or quantify system-level progress toward achieving the coequal goals if multiple adaptive management efforts are not based on a consistently applied step-wise, structured approach to incorporating scientific information into decision-making or are in other respects incomplete or~~,~~ nonintegrated~~, or fail to consider system-wide and local effects~~. Under the Delta Science Plan, adaptive management implementation will be integrated through a Restoration Framework, a Water Management Framework, and Delta Science Program Adaptive Management Liaisons (Ch 3).

Identifying, Maintaining, and Advancing the "State of Delta Knowledge"- The state of knowledge of the Delta system is advancing rapidly and distributed across many institutions, which makes it difficult to assimilate in a timely manner. This plan will facilitate the maintenance and growth of Delta-wide knowledge through the activities of the Science Synthesis Team, Policy Science Team, and the Delta Science Program. The Science Synthesis Team and Policy Science Team will play key roles in establishing Delta-wide approaches for prioritizing research (Ch 4.1), integrating monitoring and associated research (Ch 4.2), and conducting targeted and ongoing synthesis activities (Ch 4.5). The Delta Science Program with others will facilitate Delta-wide approaches to data management and accessibility (Ch 4.3), shared models (Ch 4.4), and independent peer review (Ch 4.6). To more effectively inform policy and management decisions and the public, this plan develops a number of information sharing avenues (Ch 4.7).

***Excerpt from Chapter 2 beginning on page 12:**

Actions

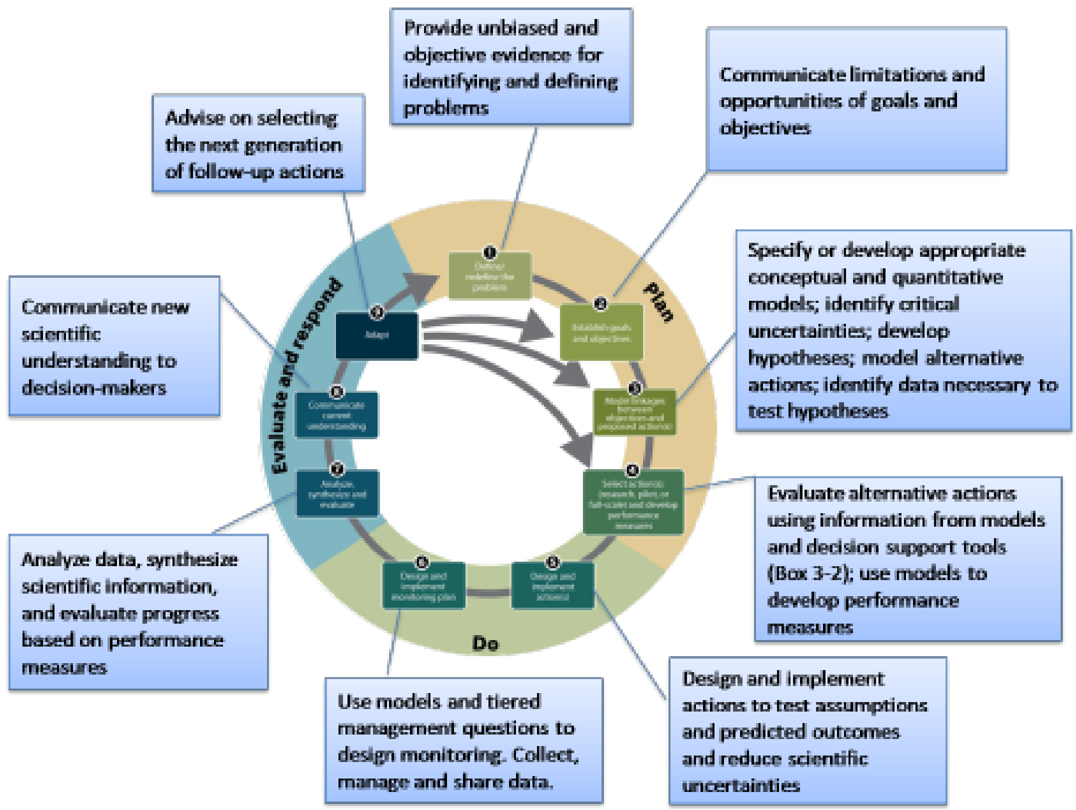
2.1 Establish a Policy-Science Team (PST) to direct science activities toward the decisions of today while researching the anticipated challenges of the future. Directors of federal and State agencies and science leaders will together identify "grand challenges" to inform the development and updates to the Action Agenda and associated science research agendas. This team is also the forum for Directors to explore issues directly with leaders of the scientific community and for scientists to fully understand what science is needed to support decisions and how this information can be best used. The PST will also direct committees as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs. The objective of the PST is to ensure there is a high level of trust and understanding between decision makers and the community of scientists on whom they depend. This enhanced communication will assist the delineation between the contribution of science and the essential value judgments that must go into each decision.

The objective of the PST is to ensure there is a high level of trust and understanding between decision makers and the community of scientists on whom they depend. This enhanced communication will assist the delineation between the contribution of science and the essential value judgments that must go into each decision.

Membership will include the Directors of federal and State agencies with water and environmental decision-making responsibilities in the Delta, representatives of the public water agencies responsible for financing and implementation of the Bay Delta Conservation Plan, and science leaders appointed by the Delta Lead Scientist. The science members will include a subset of the Science Synthesis Team (Action 2.2) and invited science leaders on the topic under consideration (i.e., the IEP Lead Scientist, BDCP Science Manager, Leading Academic Researchers, and Agency Research Program Directors). The PST will be co-chaired by a rotating Agency Director and the Delta Lead Scientist, and facilitated by the Delta Science Program.

The PST will meet to provide overarching direction and set the "grand challenges" for developing and updating the Action Agenda. The PST also meets to (a) receive early notice of findings in the SBDS, (b) address major science issues at the request of a Director or Delta Lead Scientist, (c) provide overarching direction at the start of a 4-year Action Agenda process, (d) plan specific activities, such as Town Hall meetings at the Bay-Delta Science Conference, (e) receive scientific feedback or information. The PST will meet at least once per year.

***Excerpt from Chapter 3 beginning on page 17:**



Box	Changes proposed, if any
1	Conduct a needs assessment; provide unbiased and objective evidence for identifying and defining the problem(s)
2	Communicate limitations and opportunities of goals and objectives; define the spatial and temporal limits for analysis
3	Specify or develop appropriate conceptual models; develop candidate management actions based on conceptual models; identify data available to assess the efficacy of alternative actions; identify critical uncertainties
4	Evaluate alternative actions using information from conceptual and quantitative models as well as other decision support tools; verify and validate models, including variables analyzed; use models to develop performance measures
5	No change
6	No change
7	Archive and analyze data, synthesize scientific information, and evaluate progress based on performance measures
8	No change
9	Advise on continuing to implement the action(s) or selecting the next generation of action(s); re-evaluate conceptual and quantitative models; adjust monitoring as necessary

Box 3-2 Decision Support Tools for Adaptive Management

Clearly articulated conceptual models that specify key state variables, describe their dynamic interrelationships, and project consequences of alternative management actions are a key component of adaptive management (Walters 1986). Models are extremely valuable because they require the author(s) to specify~~for formalizing~~ the predicted link between management objectives and proposed actions to clarify how and why each action is expected to contribute to those objectives. They also provide a venue to identify areas of uncertainty, assess the likelihood of success, identify potential restoration or water management actions, develop expectations and performance measures, and define monitoring needs.

The Delta Regional Ecosystem Restoration Implementation Plan conceptual models were developed for the purpose of showing the characteristics and dynamics of the Delta ecosystem, qualitatively predicting ecosystem and species response to specific changes in ecosystem attributes, and providing the science-based information needed to determine whether a restoration action would result in (or contribute to) a desired management outcome. These models are valuable tools themselves, but were designed to provide information for use in structured assessments of proposed restoration actions through the DRERIP Action Evaluation Procedure and Decision Support Tool. The Delta Science Program will build upon ~~expand the utility of~~ this tool so that it can be utilized to inform water management decisions, including by elaborating upon the steps in the structured decision-making process necessary to move from specification of conceptual models through development of candidate restoration (and other management) actions to construction and use of quantitative models that use available data to evaluate candidate actions, and make it an integral component of the Water Management Framework.

Problem

Past attempts to adaptively manage Delta water operations and habitat restoration have rarely proceeded in sequence through each step in~~covered~~ the full adaptive management cycle ~~(Plan, Do, Evaluate and Respond).~~. System-level progress toward achieving the coequal goals ~~might~~ will not be possible if multiple adaptive management efforts are not based on a consistently applied step-wise, structured approach to incorporating scientific information into decision-making or are in other respects incomplete or~~,~~ nonintegrated~~, or fail to consider system-wide and local effects~~.

* * *

Actions

3.1 The Delta Science Program, in collaboration with key partners, will co-host a summit on adaptive management with national and international experts and local proponents from federal, State and local agencies, non-governmental organizations, private organizations and academia. The summit participants will explore the development and use of guidelines (such as Restoration and Water Management Frameworks) and venues (such as the Delta Restoration Network) to support collaborative science-based adaptive management in the Delta.

3.2 Develop a Restoration Framework to guide adaptive management of Delta ecosystem restoration actions and a Water Management Framework to guide adaptive management of Delta water management actions. Framework attributes include:

- i. Integration of adaptive management activities to improve nesting of adaptive management projects into landscape- scale efforts, shared learning and efficient use of resources;~~.~~
- ii. Institutional arrangements to sustain scientific assessment and support rapid, nimble, and authoritative management decisions at appropriate time intervals (water operations decisions generally occur at more frequent intervals than habitat restoration decisions);~~.~~
- iii. Use of conceptual models including landscape-scale conceptual models for priority restoration areas based on historical ecology and latest science;
- iv. Emphasis on hypothesis-testing and linkage to companion science programs;
- v. Use of broadly accepted and transparent quantitative models to analyze alternative futures (short- and long-term) and address "what if" questions;
- vi. Expert evaluation and peer review of project design vii. Monitoring, data management and evaluation consistent with system-wide efforts and Delta Science Plan recommendations;
- viii. Focused synthesis and communication of the state of knowledge needed to inform adaptive management decisions; and
- ix. Scientific oversight by the Delta Independent Science Board.

3.3 Utilize the Restoration and Water Management Frameworks through new or established regional and system-wide team efforts such as the Delta Conservancy's Delta Restoration Network.

3.4 Establish a team of Delta Science Program staff members with expertise in adaptive management. These staff members serve as Adaptive Management Liaisons to their counterparts in agencies and organizations that are planning and implementing adaptive management. Build DSP staff capacity to assist project proponents to develop and implement effective adaptive management programs and projects including Delta Plan covered actions (Box 3-4). This includes assistance in considering and using established guidelines for adaptive management (Appendix 3) in the planning stages of an adaptive management program.

3.5 Explore the efficacy of voluntary certification of adaptive management plans, programs and projects.

3.6 The Delta Science Program will build upon~~expand the utility of~~ the DRERIP Action Evaluation Procedure and Decision Support Tool so that it can be utilized to inform water management decisions and make it an integral component of the Water Management Framework.

3.7 Develop a shared tracking system for all adaptive management programs and a system-wide monitoring and evaluation program to assess the cumulative effects of individual adaptive management programs. Information can be used to update large-scale adaptive management plans including the Delta Plan, BDCP and Bay-Delta Plan.

***Excerpt from Chapter 4 beginning on page 25:**

4.2 Monitoring and Associated Research

Environmental monitoring provides data that are essential ingredients of the scientific enterprise because they allow scientists to attempt to falsify hypotheses regarding cause-effect relationships, interpret the findings that emerge from such exercises, and synthesize the information in order to inform~~important scientific information that helps~~ policy makers, managers, and the public as society works to address challenging environmental issues. The term “monitoring” covers both scientific research activities and conservation planning (or management) activities~~a wide variety of sampling, analysis, measurement, and survey activities~~ (Karanth et al. 2004). It is often defined as “periodic or continuous collection of data (measured parameters) using consistent methods to determine the status (or condition) and trends of environmental or socio-economic characteristics.” A comprehensive Delta monitoring program would provide the basis for policy decisions and management actions and also track~~follow~~ environmental change as ~~policy~~ decisions and actions are implemented to inform subsequent assessment of the efficacy of those decisions and actions as well as the conceptual and quantitative models that were the basis for the decisions and actions~~and provide information to support adaptive management~~. ~~It should include information about water supply, the ecosystem, and the Delta as place.~~

Comment [A1]: Karanth K. Ullas et al. 2004. Photographic sampling of elusive mammals in tropical forests, in W.L. Thompson, ed., Sampling rare or elusive species. Island Press. Washington, D.C.

In the Delta, ~~environmental monitoring has long played an important role and~~there are many long-term monitoring programs~~ exist~~. For example, the Interagency Ecological Program (IEP) has been monitoring ~~various~~multiple ~~kinds of~~ fish species~~es~~ and ecological parameters (e.g., water flow, water quality, phytoplankton, zooplankton, benthic invertebrates) for decades. These long-term data sets are valuable, but over that same period the composition and quantity of target organisms and parameters has changed as have our understanding of the life history of the target organisms and physical properties of the parameters. Furthermore, marked advances in multiple disciplines inform the design of sampling schema across pertinent spatial and temporal gradients as well as the best available tools and techniques to provide meaningful real time measures of response variable, stressor, and background variable conditions. In part, in recognition of these facts, a~~A~~dditional programs soon will be added as part of the new BDCP, if approved, and the Delta Regional Monitoring Program; both programs are currently under development.

-None of the existing and planned programs capture or coordinate all Delta monitoring in the comprehensive manner needed to support the Delta Plan, BDCP, other plans, programs, and regulatory requirements. No shared strategy exists for Delta monitoring. We propose the development of a comprehensive monitoring strategy that will allow for better design, coordination, and integration of Delta monitoring. This comprehensive strategy would:

- Identify and characterize the full complement of environmental attributes, including water-quality, physical landscape, and biotic factors that are believed to affect the

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status and population trends in the Delta's native, at-risk fishes and other ecosystem elements of concern.

- Facilitate efforts to rank the environmental factors according to their degree of impact or irreversible consequences on resources.
- Access available conceptual models of the species and ecological systems of concern, outlining pathways from water-quality stressors to ecological effects on fishes and other environmental attributes.
- Select an "optimal" set of direct measures and environmental-condition indicators that are efficient at detecting effects on target species and essential resources upon which those species depend.
- Determine detection limits for those measured variables and condition indicators.
- Establish contingent decision values (thresholds or trigger points) for the measured variables and indicators.
- Establish clear connections between monitoring outputs and prospective management decisions.

The strategy~~is plan~~ would be based on a common monitoring framework and would build on recent efforts sponsored by the Delta Science Program, the California Water Quality Monitoring Council, and others. Inherent to this monitoring ~~framework~~ strategy is the appropriate and timely assessment, reporting, and publication of monitoring results.

Problem

A shared strategy for integrated monitoring in the Delta does not exist. Specific problems include: inadequate conceptual foundation (purpose), the lack of a comprehensive monitoring framework based on questions common to multiple agencies, lack of a common assessment approach, absence of an experimental design, inadequate reporting on performance or environmental change, and inadequacies in data documentation (metadata), data management and data exchange. These same problems are associated with monitoring activities associated with data collection for water demand, above-ground storage, supply, conveyance, beneficial re-use and other water management monitoring related to Delta water supply. These difficulties in coordination are often compounded by inadequate resources for activities beyond monitoring itself (e.g. data quality assurance, data and metadata entry, systematic and regular analysis, and communication of results).

Objectives

- Develop a comprehensive inventory of monitoring in the Delta compiled from existing inventories but extended across a broader range of disciplines (e.g., compiled monitoring efforts by the Regional Water Quality Control Board, Region 5; State Water Quality Control Board, and others). This inventory will show where overlaps between monitoring programs exist and where gaps in data collection need to be filled.

- Assemble or develop conceptual models with the purpose of developing a common monitoring framework and prioritized questions or hypotheses. Existing conceptual models such as those built by the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) and the IEP Pelagic Organism Decline Investigations can be used as a resource. It may be necessary to construct additional models following a similar protocol.
- Identify a small number of Grand Monitoring Challenges. For example Luoma et al. (2010) identified four overarching Grand Monitoring Challenges:

    1. To understand how the ecosystem is changing in response to changes in infrastructure and water management actions that affect water supply reliability;
    2. To understand how the ecosystem is changing in response to ecosystem restoration activities and to changes in regulations and rulings to protect the environment;
    3. To understand how the ecosystem is changing in response to external forces (e.g., climate change, sea level rise, ocean processes);
    4. To understand how the ecosystem is changing in response to external changes in human activities like population growth, changes in land use, changes in agricultural runoff, and inadvertent importation of exotic species.

- Develop a framework that will provide a common focus for existing monitoring programs and monitoring plans. Elements of such a framework might include:

    1. An ~~simple,~~ overarching, common goal: track environmental change through time, in response to four Grand Monitoring Challenges.
    2. Identification of important environmental attributes (IEAs) that are likely to change; and the indicators, metrics and measurements that allows those attributes to be tracked and their change to be interpreted. These indicators would be developed by coordinating a finite set of carefully selected data from across existing monitoring programs using a strict set of criteria for choices (e.g. Luoma et al. 2010).
    3. Identify from this baseline data set a smaller set of SMART5 targets against which to report on change.
    4. Provide a strategy and resources for ongoing evaluation and interpretation (assessment) of monitoring data.
    5. Provide a structure and approach for regular reporting of results to policy makers and the public.
    6. Develop a system for appropriate, sustained data management across coordinated programs.

- Build a sense of common purpose among different institutional monitoring programs with their own missions.

***Proposed definition to add to Glossary:**

Science - A process for organizing knowledge in the form of testable explanations and predictions.

***Excerpt from Appendix 1, beginning on page A1-3:**

Panel Report(s)

The Delta Science Program may suggest grammatical or formatting edits of a draft report to improve it, but will not otherwise substantively amend a review panel report. The content, substance, and recommendations of a review panel report are those of the review panel, not the Delta Science Program or Delta Stewardship Council. The Delta Science Program will post the report after approval of the panel. The Delta Science Program may provide a courtesy copy of the report to the agency that produced the materials subject to review in advance of posting the report provided the agency agrees not to disclose or comment upon the report until it is available to the public (except to the extent the agency is required by law to do so). If the agency that produced the materials subject to review chooses to develop a written response, the response will be posted along with the review at the time it becomes available.

Appendix 3: Adaptive Management Guidelines

The following are suggested guidelines for each of the nine steps of the Delta Plan adaptive management framework to help proponents incorporate adaptive management into their project plans.

1) Define/Redefine the Problem

- Project proponents and stakeholders articulate the problem statement as a group.
- Link management problem with relevant scientific knowledge and conceptual models.
- Project proponents identify funding source(s) for carrying out the adaptive management process as part of the certification of consistency with Policy GP 1 of the Delta Plan.

2) Establish Goals and Objectives

- Articulate specific objectives.
- Place objectives into larger landscape/watershed context.
- Through early engagement with the Delta Science Program Adaptive Management liaison(s), develop shared understanding of the limitations and opportunities of goals and objectives based on conceptual models.

3) Model Linkages between Objectives and Proposed Action(s)

- Gather and critically assess pertinent data, analyses, and findings.
- Synthesize scientific information.
- Identifiy pertinent scientific information to assess candidate management actions; u~~U~~se ~~conceptual and quantitative~~operational models (including landscape-scale and community models developed under the Delta Science Plan Action 4.4.3) to ~~develop~~evaluate ~~hypotheses~~alternative actions~~,~~; determine the range of potential outcomes (benefits and risks) of alternative actions;~~, and~~ verify and validate models; determine additional~~what~~ information needs to~~is needed to test hypotheses, analyze results, and~~ reduce critical uncertainties.

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4) Select Action(s) and Identify Performance Measures

- ~~Use the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Action Evaluation Procedure and accompanying worksheets as an organizing tool for evaluating project objectives and initial range of actions.~~
- Articulate expected benefits and risks of actions designed to meet project objectives.
- Select adequate and realistic performance measures based on desired outcomes, project conceptual model and simulation models.
- Ensure consistency and integration with system-wide performance measures.

5) Design and Implement Actions

- Use the conceptual and operational models ~~and Action Evaluation Procedure~~ to evaluate various designs.
- Consider the range of outcomes under various alternative actions ~~("alternative futures")~~ through modeling and expert ~~opinion~~ evaluation.

- Consider effects on other current actions and determine future actions that could be precluded by this action.
- Design action(s) and appropriate monitoring approach to reduce uncertainty, test model predictions, and integrate into related research programs.

6) Design and Implement Monitoring

- Based on the models and tiered management questions associated with the project, determine the most appropriate statistical design of the proposed monitoring program, including linkage to: companion research effort, modeling, performance measures, and system-wide monitoring, including the collaborative and comprehensive Delta monitoring program (Action 4.2.3).
- Document other data sources to be used in assessment.
- Develop funding source and identify responsible entities for monitoring.
- Develop data management plan for project.
- Collect and share data via an open Delta cyber-infrastructure (Action 4.3.1).

7) Analyze, synthesize, and evaluate

- Analyze data and use shared mechanisms and protocols for synthesis (Actions 4.5.1) to assess the efficacy ~~learn the effects~~ of the action taken.
- Evaluate progress based on performance measures and utilize independent scientific ~~peer~~ review protocols to check the integrity of the science (Actions 4.6.1 - 4.6.3).

8) Communicate Findings

- Communicate current understanding through science-management team discussions and communication tools (Actions 4.7.1 - 4.7.4)
- Provide adequate opportunities for all interested parties to engage in process.

9) Adapt

- Re-define the problem being addressed.
- Adjust the goals and objectives.
- Re-calibrate models with new data, as appropriate.
- Adjust management actions if necessary, based on outcomes and responses to implementation in Step 5.
- Evaluate robustness of management, regulatory, and policy structures to implement change and adaptation on this or future related projects.